Elektro-Automatik

60 kW

DATASHEET

EA-PUL 10000 6U

Programmable Electronic DC Loads with Energy Recovery

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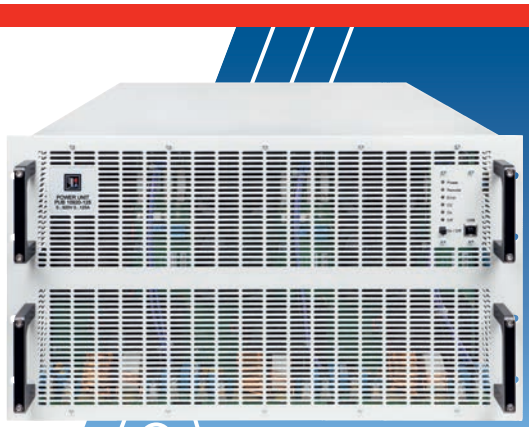


Features

- Wide range input: 380 V - 480 V, +10%, 3ph AC
- Active Power Factor Correction, typical 0.99
- Regenerative, with energy recovery into the grid
- Very high efficiency of up to 96%
- High performance with up to 60 kW per unit
- Voltages from 0 - 360 V up to 0 - 2000 V
- Currents from 0 - 80 A up to 0 - 480 A
- Flexible power regulated DC input stages (autoranging)
- Regulation modes CV, CC, CP, CR with fast crossover
- Digital regulation, high resolution with 16 Bit ADCs and DACs, selection of voltage controller speed
- Galvanically isolated Share-Bus for parallel operation of all power classes in the 10000 series
- Master-slave bus for parallel operation of up to 64 units of all power classes in the 10000 series
- Command languages and drivers: SCPI and ModBus, LabVIEW, IVI

Built-in interfaces

- USB
- Ethernet
- Analog
- Master-Slave-Bus
- Share-Bus
- USB (front panel)

Optional interfaces

- CAN
- CANopen
- RS232
- Profibus
- EtherCAT
- Profinet, with one or two ports
- Modbus, with one or two ports
- Ethernet, with one or two ports

Software

- EA-Power Control

Options

- Water Cooling in stainless steel
- Function generator

Technical data

General specifications	
AC input	
Voltage, Phases	380 V - 480 V ±10%, 3ph AC
Frequency	45 - 65 Hz
Power factor	ca. 0.99
Leakage current	<10 mA
Phase current	≤110 A @ 400 V AC
Overvoltage category	3
DC input static	
Load regulation CV	≤0.05% FS (0 - 100% load, constant AC input voltage and constant temperature)
Line regulation CV	≤0.01% FS (380 V - 480 V ±10% AC input voltage, constant load and constant temperature)
Stability CV	≤0.02% FS (during 8 h of operation, after 30 minutes warm-up, at constant AC input voltage, load and temperature)
Temperature coefficient CV	≤30ppm/°C (after 30 minutes of warm-up)
Compensation (remote sense)	≤5% $U_{Nominal}$
Load regulation CC	≤0.1% FS (0 - 100% load, constant AC input voltage and constant temperature)
Line regulation CC	≤0.01% FS (380 V - 480 V ±10% AC input voltage, constant load and constant temperature)
Stability CC	≤0.02% FS (during 8 h of operation, after 30 minutes warm-up, at constant AC input voltage, load and temperature)
Temperature coefficient CC	≤50ppm/°C (after 30 minutes of warm-up)
Load regulation CP	≤0.3% FS (0 - 100% load, constant AC input voltage and constant temperature)
Load regulation CR	≤0.3% FS + 0.1% FS current (0 - 100% load, constant AC input voltage and constant temperature)
Protective functions	
OVP	Overvoltage protection, adjustable 0 - 110% $U_{Nominal}$
OCP	Overcurrent protection, adjustable 0 - 110% $I_{Nominal}$
OPP	Overpower protection, adjustable 0 - 110% $P_{Nominal}$
OT	Overtemperature protection (DC Input shuts down in case of insufficient cooling)
DC input dynamic	
Rise time 10 - 90% CC	≤2 ms
Fall time 90 - 10% CC	≤2 ms
Insulation	
AC input to DC input	3750 Vrms (1 minute, creepage distance >8 mm)
AC input to case (PE)	2500 Vrms
DC input to case (PE)	Depending on the model, see model tables
DC input to interfaces	1000 V DC (models up to 360 V input), 1500 V DC (models from 500 V input)
Interfaces digital	
Built-in, galvanically isolated	USB, Ethernet (100 MBit), USB front panel, all for communication
Optional, galvanically isolated	CAN, CANopen, RS232, ModBus TCP, Profinet, Profibus, EtherCAT, Ethernet
Interfaces analog	
Built-in, galvanically isolated	15 pole D-Sub
Signal range	0 - 10 V or 0 - 5 V (switchable)
Inputs	U, I, P, R, remote control on/off, DC input on/off, resistance mode on/off
Outputs	Monitor U and I, alarms, reference voltage, DC input status, CV/CC regulation mode
Accuracy U / I / P / R	0 - 10 V: ≤0.2%, 0 - 5 V: ≤0.4%
Device configuration	
Parallel operation	Up to 64 units of any power class in series 10000 starting from 5 kW, with Master-Slave bus and Share-Bus

General specifications	
Safety and EMC	
Safety	EN 61010-1 IEC 61010-1 UL 61010-1 CSA C22.2 No 61010-1 BS EN 61010-1
EMC	EN 55011, class A, group 1 CISPR 11, class A, group 1 FCC 47 CFR part 15B, unintentional radiator, class A EN 61326-1 include tests according to: - EN 61000-4-2 - EN 61000-4-3 - EN 61000-4-4 - EN 61000-4-5 - EN 61000-4-6
Safety protection class	1
Ingress Protection	IP20
Environmental conditions	
Operating temperature	0 - 50 °C (32 - 122 °F)
Storage temperature	-20 - 70 °C (-4 - 158 °F)
Humidity	≤80% relative humidity, non-condensing
Altitude	≤2000 m (≤6,600 ft)
Pollution degree	2
Mechanical construction	
Cooling	Forced air flow from front to rear (temperature controlled fans), optional: water cooling
Dimensions (W x H x D)	Enclosure: 19" x 6U x 668 mm (26.3 in)
Weight	76 kg (168 lb)
Weight with water cooling	82 kg (180 lb)

Technical specifications	PUL 10360-480	PUL 10500-360	PUL 10750-240	PUL 10920-250
DC output				
Voltage range	0 - 360 V	0 - 500 V	0 - 750 V	0 - 920 V
Ripple in CV (rms)	≤55 mV (BWL 300 kHz)	≤70 mV (BWL 300 kHz)	≤200 mV (BWL 300 kHz)	≤250 mV (BWL 300 kHz)
Ripple in CV (pp)	≤320 mV (BWL 20 MHz)	≤350 mV (BWL 20 MHz)	≤800 mV (BWL 20 MHz)	≤1200 mV (BWL 20 MHz)
U_{Min} for I_{Max} (sink)	2.5 V	1.1 V	1.2 V	2 V
Current range	0 - 480 A	0 - 360 A	0 - 240 A	0 - 250 A
Power range	0 - 60000 W	0 - 60000 W	0 - 60000 W	0 - 60000 W
Resistance range	0.025 Ω - 45 Ω	0.04 Ω - 85 Ω	0.1 Ω - 185 Ω	0.125 Ω - 275 Ω
Output capacitance	3480 µF	1560µF	765 µF	465 µF
Efficiency sink/source (up to)	95.8% *1	96.5% *1	96.5% *1	96.5% *1
Insulation				
Negative DC pole <-> PE	±1000 V DC	±1500 V DC	±1500 V DC	±1500 V DC
Positive DC pole <-> PE	+1000 V DC	+2000 V DC	+2000 V DC	+2000 V DC
Article numbers				
Standard	01133009	01133010	01133011	01133012
Standard + Water Cooling	01663001	01663002	01663003	01663004

*1 At 100% power and 100% input voltage
BWL = band width limit

Technical specifications	PUL 11000-160	PUL 11500-120	PUL 12000-80	
DC output				
Voltage range	0 - 1000 V	0 - 1500 V	0 - 2000 V	
Ripple in CV (rms)	≤300 mV (BWL 300 kHz)	≤400 mV (BWL 300 kHz)	≤500 mV (BWL 300 kHz)	
Ripple in CV (pp)	≤1600 mV (BWL 20 MHz)	≤2400 mV (BWL 20 MHz)	≤3000 mV (BWL 20 MHz)	
U_{Min} for I_{Max} (sink)	3.4 V	3.2 V	3.7 V	
Current range	0 - 160 A	0 - 120 A	0 - 80 A	
Power range	0 - 60000 W	0 - 60000 W	0 - 60000 W	
Resistance range	0.2 Ω - 325 Ω	0.4 Ω - 750 Ω	0.85 Ω - 1350 Ω	
Output capacitance	387 µF	173 µF	85 µF	
Efficiency sink/source (up to)	95.8% *1	96.5% *1	96.5% *1	
Insulation				
Negative DC pole <-> PE	±1500 V DC	±1500 V DC	±1500 V DC	
Positive DC pole <-> PE	+2000 V DC	+2000 V DC	+2000 V DC	
Article numbers				
Standard	01133013	01133014	01133015	
Standard + Water Cooling	01663005	01663006	01663007	

*1 At 100% power and 100% input voltage
BWL = band width limit

General

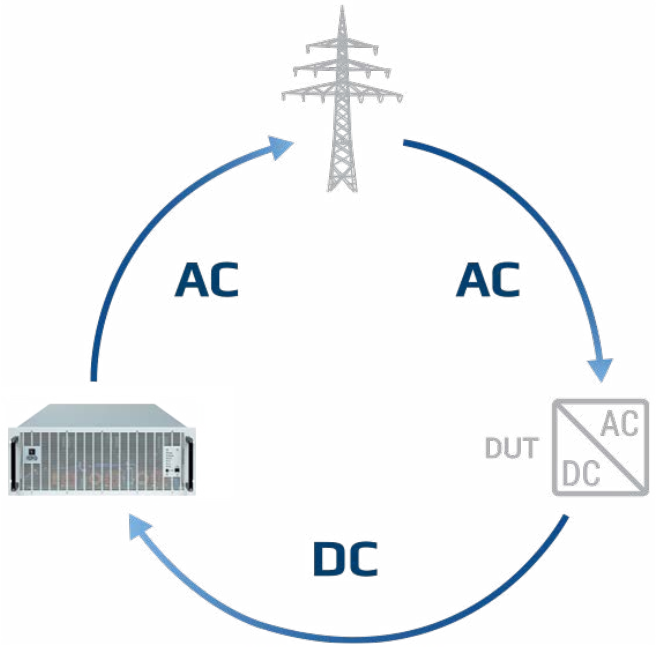
The device series PUL 10000 from EA Elektro-Automatik are programmable electronic loads. The devices are regenerative and feed the consumed DC energy back into the local or public grid with an efficiency of up to over 96%. The PUL 10000 are three-phase models which, together with the wide input range, allow operation on practically all global mains voltages. The DC voltages and currents are determined by the application and the spectrum ranges are from 0 - 80 V to 0 - 2000 V and from 0 - 40 A up to 0 - 1000 A in a single device. The DC input operates as a flexible input stage with a constant power characteristic (autoranging) with a wide voltage and current range. To achieve higher power and current all units are equipped with a Master-Slave-Bus. This enables up to 64 parallel connected devices to be combined into one system which can provide up to 3840 kW and 64000 A. Such a system works as a single unit and can use different power classes start from 5kW, only the voltage class must remain constant. In this way a user can construct a 150 kW system from two 60 kW 6U and one 30 kW 4U device from the PUL 10000 range. Furthermore, typical laboratory functionality is provided. This includes an alarm and warning management, various optional industrial interfaces, software solutions and many more functions.

AC connection

The DC electronic loads in the PUL 10000 series with 60 kW are equipped with an active PFC which provides a high efficiency at a low energy consumption. Furthermore, the devices in this series provide a wide AC voltage range. It reaches from 380 - 480 V with 3-phases. Hence the devices can be operated in the majority of global grids.

Energy recovery

The energy consumed in load mode is fed back into the connected grid with an efficiency of up to over 96%. As the energy is not converted to heat as in other loads, the energy costs are reduced. In addition, the devices generate less heat requiring less cost intensive air conditioning. One device can already be sufficient for a while range of applications, reducing investment and installation costs.



The principle of energy recovery

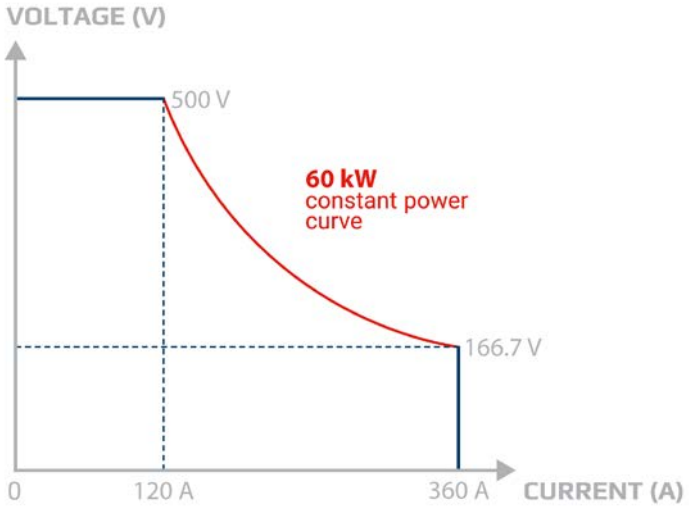
The figure above demonstrates, based on a typical application, how a „device under test“ consumes energy from the mains, converts it to DC and feeds that into an EA device. The bidirectional power supply PUL 10000 converts this energy back into an AC current and feeds it back into the grid.

DC input

The input of the electronic loads PUL 10000 with 60 kW with a DC voltage of 0 - 360 V up to 0 - 2000 V allows currents of 0 - 80 A up to 0 - 480 A. The flexible input stages (autoranging) provide the user with a wide voltage, current and power range and hence a wider field of working than traditional electronic loads.

DC connection

Connection of the DC output is via a copper rail on the back side of the device. If a system with higher performance is required, the devices are simply connected in parallel. With minimal effort devices can be linked with the vertical copper rails. A cover for contact protection is provided.



The principle of autoranging

„Autoranging“ is a term when a programmable electronic load automatically offers a wide input range of both, voltage and current, to maintain full power across a wide operation range. This type of solution allows the use of a single unit to address multiple voltage and current combinations.

Interfaces

As standard, 10000s series devices are fitted with the most important interfaces and ports which are all galvanically isolated from the DC input. There is an analog interface which can be parameterized for input and output, control and monitoring, of 0 - 5 V or 0 - 10 V for voltage, current, power and resistance, assorted inputs and outputs as well as USB and Ethernet ports. Further optional industrial interface for plug & play slot complete the portfolio:

- CAN
- CANopen
- RS232
- Profibus
- EtherCAT
- Profinet, with one or two ports
- Modbus, with one or two ports
- Ethernet, with one or two ports

High performance systems

High power applications can be covered with high power systems of up to 3840 kW. These are achieved by using the DC inputs of multiple PUL 10000 devices with vertical copper rails in parallel. Thus, a 19” cabinet with 42 U can provide a system with 300 kW occupying only 0.6 m² (6.5 sqft) of floor space. The Master-Slave-Bus allows for up to 13 cabinets with a maximum of 64 units with 60 kW each to behave as one unit.

Master-slave bus and Share-Bus

If the integrated master-slave bus and Share-Bus are used, a multi device system behaves as a single device. The master-slave bus and Share-Bus are simply connected between each device. With the master-slave bus the system data, such as total power and total current, are collected and shown on the master device. Warnings and alarms of the slave devices are shown clearly in the display. The Share-Bus equal load distribution to the individual devices.

Example representation

In this illustration you can see a fully assembled and wired 240 kW system

Applications

Battery test for electro mobility

A typical application for the electronic loads with energy recovery from EA Elektro-Automatik is the testing of the electrical characteristics of a battery. The wide application spectrum covers cell, module or pack tests, the determination of the SOH (State-of-Health) for a second life classification as well as the End-of-Line (EOL) test. These applications put many demands on power electronics which are fulfilled by the PUL 10000 range. The excellent features of this device range are: measurement of voltage and current with the required accuracy and performance, reproducibility and reliability of these data and the flexible usability. Whether in an automated test system or in an integrated battery test, all possibilities are open to the user. Furthermore, the devices are clearly economical with efficiencies of up to over 96%.

Fuel cell test

The devices in the PUL 10000 range may be used for testing the electrical features of fuel cells, fuel cell stacks and fuel cell systems. Here they generate highly accurate and reproducible results in all electrical modes. To test the resistance, performance, and active life of a fuel cell quickly and economically users can readily incorporate the devices into an automatic test system. The feedback capability guarantees high level of energy and cost efficiency. If higher currents are needed for testing a complete fuel cell system, then multiple devices can be connected in parallel in a Master-Slave-Mode system. High accuracy and performance are maintained here.

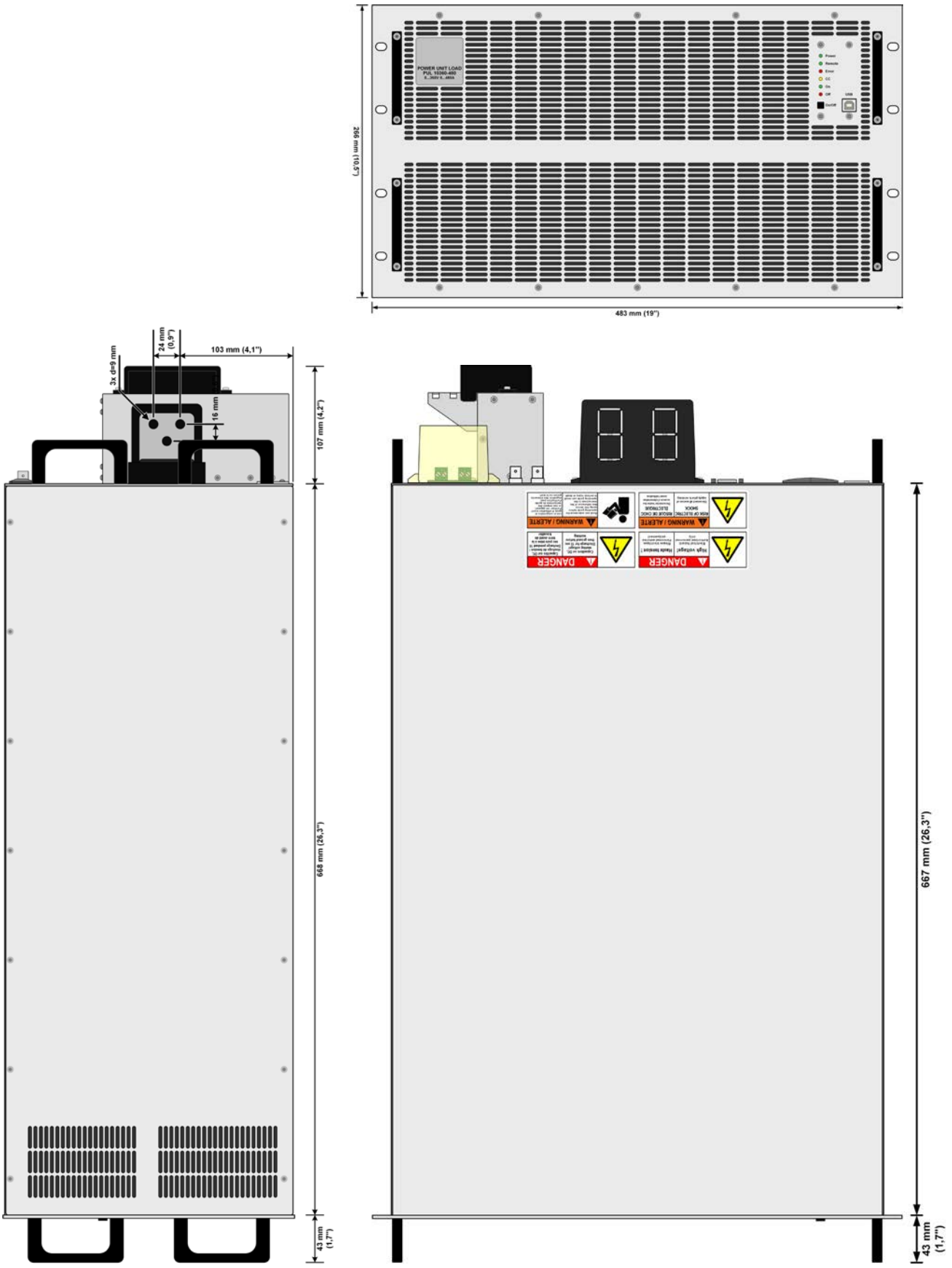
On-board charger test

In an on-board charger (OBC) test the electrical features must be tested under various conditions. This requires a flexible test system which also provides test data. With the sequencing and logging functions of the software EA-Power Control it allows data to be exported and saved. In this way applications can instantly generate reproducible test results based on dynamic and highly accurate set point and measurement data. To avoid competition between two separate control loops of the device under test (DUT) and the testing device, the voltage regulation speed of the electronic load is adjustable. The modes Normal, Fast and Slow allow the PUL 10000 devices to be adapted the control characteristics of the on-board charger.

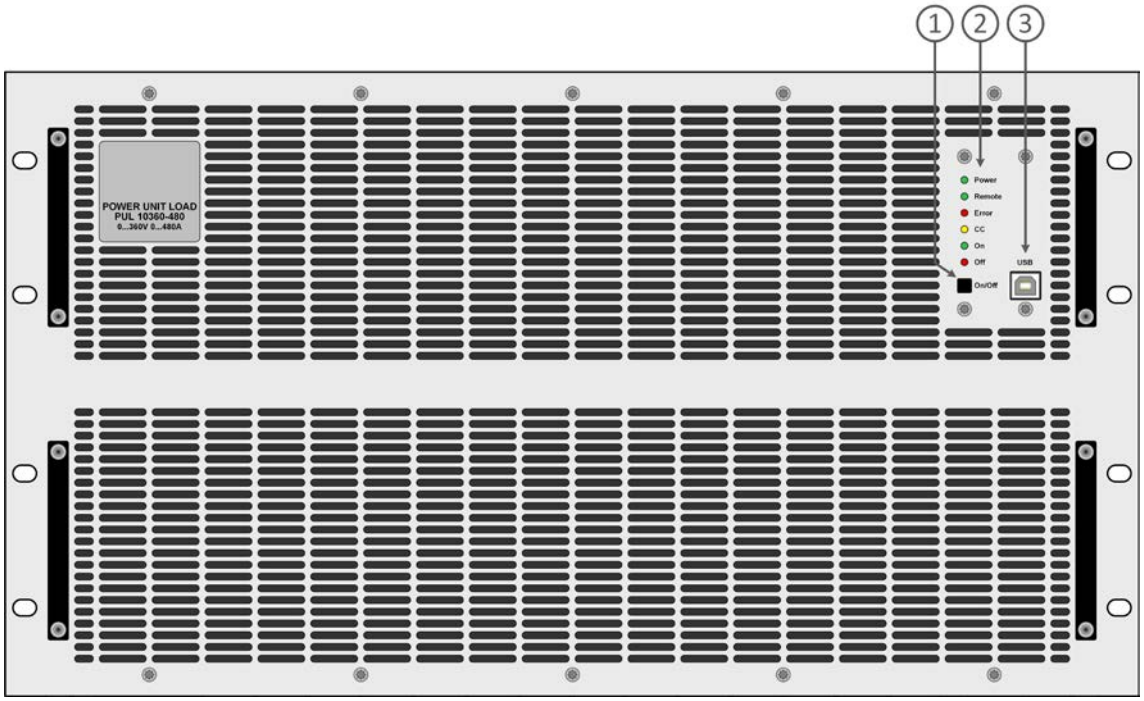
Battery recycling

The electronic loads with energy recovery of the PUL 10000 range enable retired batteries from electric vehicles to be considered for a possible further use. Assessment of the battery pack starts with a State of Health (SOH) check to determine if a second life is feasible. This standard integral function can be initiated with one clic. If this check shows too little rest capacity, then the battery must be fully discharged before recycling. The autoranging of the devices guarantees the maximum possible total discharge though the high load current, even with voltages under 2 V. The mains feedback to the power grid up to over 96% efficiency makes this process highly cost effective.

Technical drawings PUL 10000 6U

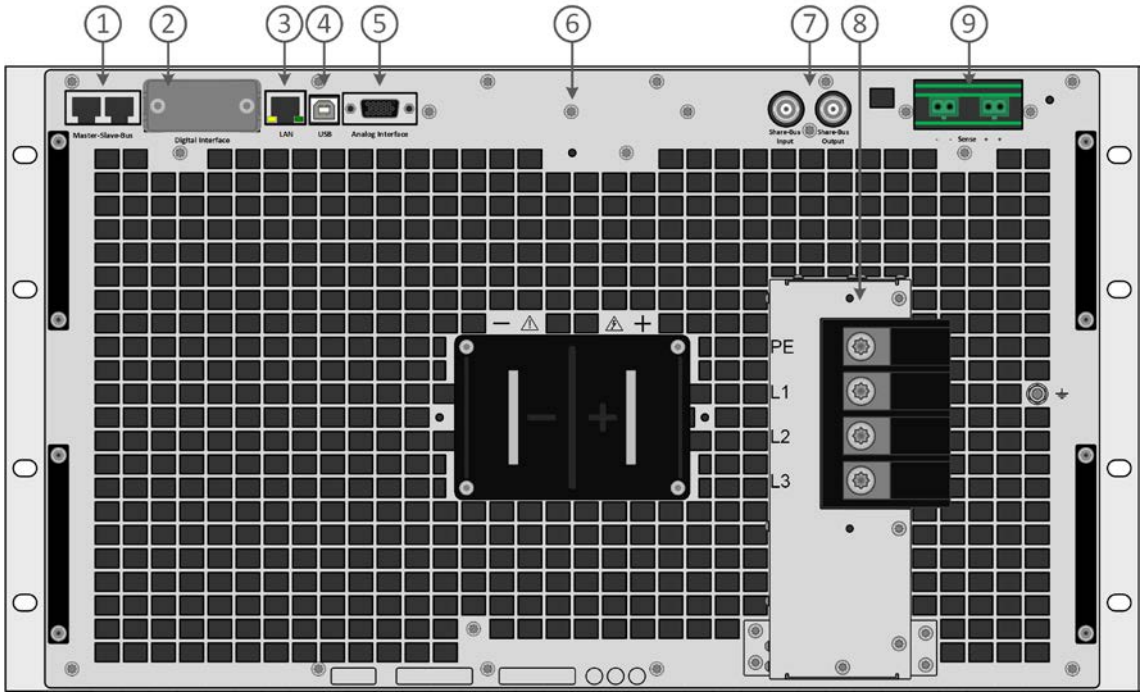


Front panel description PUL 10000 6U



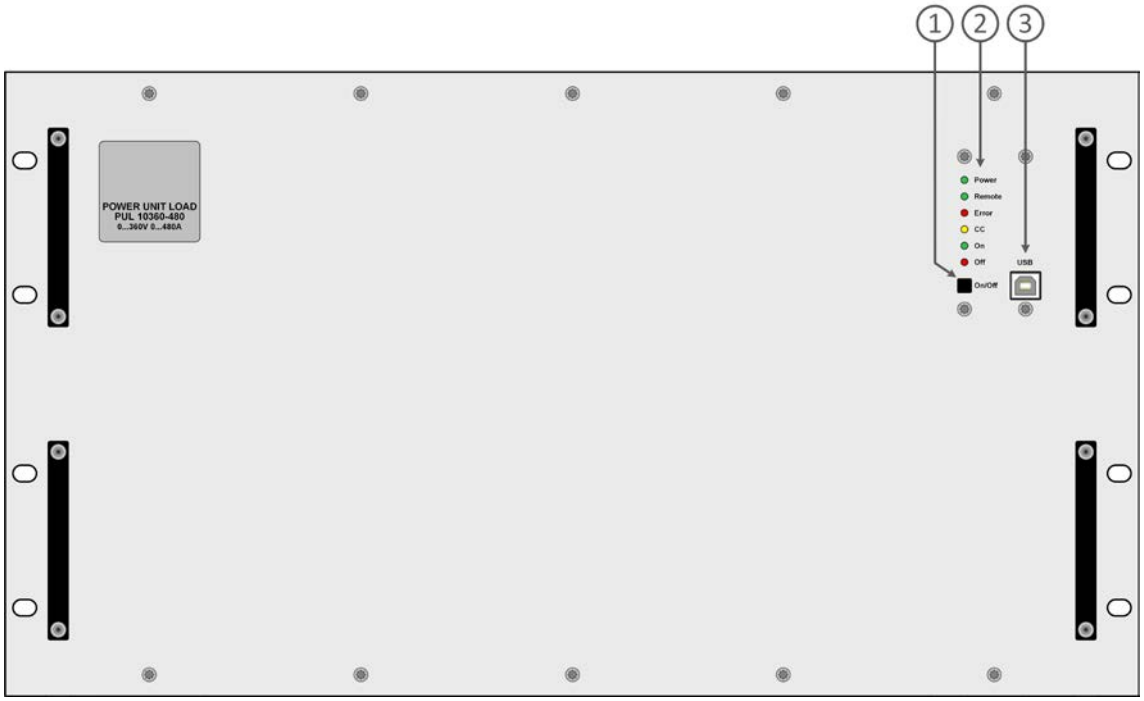
1. On / Off push-button
2. LED status display
3. USB Interface

Rear panel description PUL 10000 6U



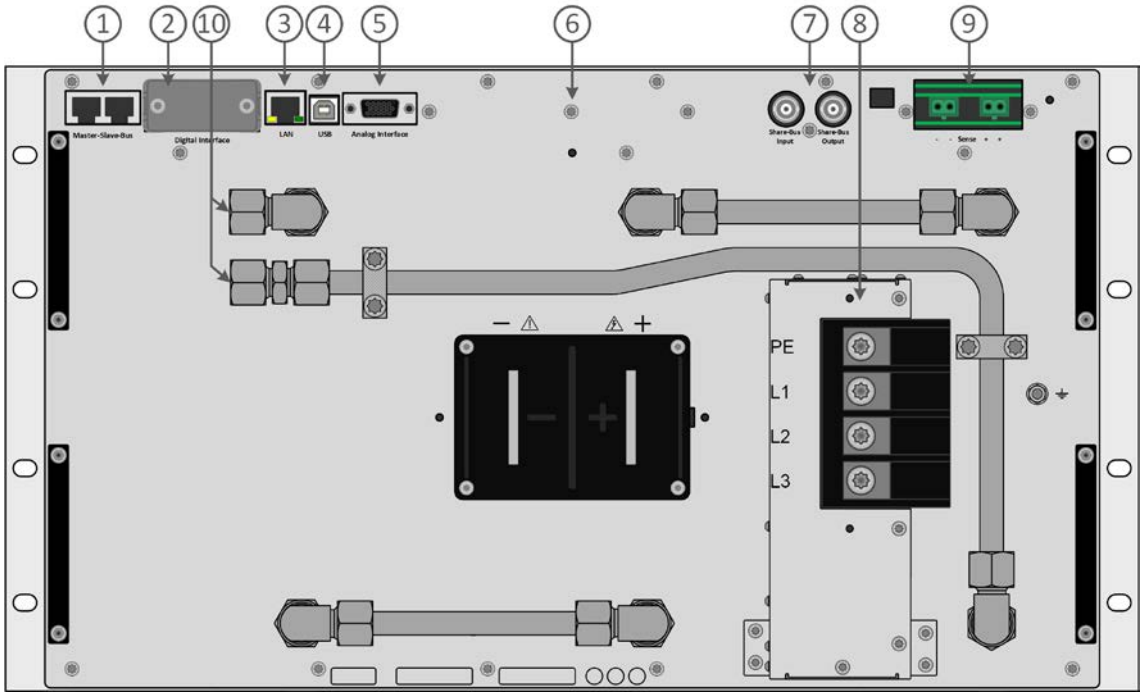
1. Master-Slave-Bus connectors to set up a system for parallel connection
2. Slot for interfaces
3. Ethernet interface
4. USB interface
5. Connector (DB15 female) for isolated analog programming, monitoring and other functions
6. DC output connector (copper blades)
7. Share-Bus connectors to set up a system for parallel connection
8. AC input connector
9. Remote sense connectors

Front panel description PUL 10000 6U WC (water cooling option)



1. On / Off push-button
2. LED status display
3. USB Interface

Rear panel description PUL 10000 6U WC (water cooling option)



1. Master-Slave-Bus connectors to set up a system for parallel connection
2. Slot for interfaces
3. Ethernet interface
4. USB interface
5. Connector (DB15 female) for isolated analog programming, monitoring and other functions
6. DC output connector (copper blades)
7. Share-Bus connectors to set up a system for parallel connection
8. AC input connector
9. Remote sense connectors
10. Water inlet and outlet

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